AMENDMENTS TO THE CLAIMS

For reasons unrelated to the prior art, and instead related to territorial limitations in patent enforcement, the applicants submit herewith amended claims. The nine original claims remain unchanged (Claims 1-9). They are followed by four new claims. In independent claims 10 and 11, the applicants believe there is no new matter problem because the only effect is to reorganize the wording of claim 1 in ways that neither add nor delete any limitations. Claims 12 and 13 are independent claims for which there should be no new matter issue because they result from partitioning claim 1 except for minor word variations, the applicants believing that both the data acquisition first part of claim 1 and the data processing last part of claim 1 are separately patentable. A complete listing of the claims, as amended, is included.

AMENDED CLAIMS

1. *(Original)* A method of operating a plurality N of seismic vibrators simultaneously with continuous sweeps, and separating the seismic response for each vibrator, said method comprising the steps of:

(a) loading each vibrator with a unique continuous sweep signal consisting of $M \geq N$ segments, the i^{th} segment being of the same duration for each vibrator, $i = 1, 2, \ldots, M$;

(b) activating all vibrators and using at least one detector to detect and record the combined seismic response signals from all vibrators;

(c) selecting and recording a signature for each vibrator indicative of the motion of that vibrator;

(d) parsing the vibrator motion record for each vibrator into M shorter records, each shorter record coinciding in time with a sweep segment, and then padding the end of each shorter record sufficiently to extend its duration by substantially one listening time;

(e) forming an M x N matrix s whose element $s_{ij}(t)$ is the padded shorter vibrator motion record as a function of time t for the i^{th} vibrator and j^{th} sweep segment;

(f) parsing the seismic data record from step (b) into M shorter records, each shorter record coinciding in time with a padded shorter record of vibrator motion from step (d);

(g) forming a vector $\vec{d}$ of length M whose element d_i is the i^{th} shorter data record from the preceding step;

(h) solving for $E_j(f)$ the following system of M linear equations in N unknowns

$$S\bar{E} = \bar{D}$$

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where $S_{ij}(f)$ is the Fourier transform to the frequency (f) domain of $s_{ij}(t)$ and $D_i(f)$ is the Fourier transform of $d_i(t)$, where $i = 1, 2, \ldots M$ and $j = 1, 2, \ldots N$; and

(i) inverse Fourier transforming the $E_j(f)$ to yield $e_j(t)$.

2. *(Original)* The method of claim 1, wherein each sweep segment is selected from one of the following sweep-design categories: (a) linear, (b) nonlinear, and (c) pseudo-random.

3. *(Original)* The method of claim 1, wherein all of the N unique continuous sweeps are identical except for the phase of their segments.

4. *(Original)* The method of claim 3, wherein all N segments are identical except for phase, and the phase differences for the N sweeps are determined by the following steps: (a) constructing a reference sweep by starting with a preselected reference segment, then advancing the segment $360/M$ degrees in phase to make the second segment, then advancing the phase $360/M$ more degrees to make the third segment, and so on to generate a sweep of M segments; (b) constructing a first sweep by advancing the phase of the first segment of the reference sweep by 90 degrees; (c) constructing a second sweep by advancing the phase of the second segment of the reference sweep by 90 degrees; (d) and so on until N sweeps are constructed.

5. *(Original)* The method of claim 1, wherein each unique continuous sweep has a duration in time sufficiently long to collect all seismic data desired before relocating the vibrators.

6. *(Original)* The method of claim 1, wherein the vibrator signature record for each vibrator is a weighted sum or ground force record of the motion of that vibrator.

7. *(Original)* The method of claim 1, wherein $M = N$ and the system of linear equations $\mathbf{S}\bar{E} = \bar{D}$ is solved by matrix methods comprising the steps of deriving a separation and inversion filter $(S)^{-1}$ by inverting the matrix S, then performing the matrix multiplication $(\mathbf{S})^{-1}\bar{D}$.

8. *(Original)* The method of claim 1, wherein the system of linear equations $\mathbf{S}\vec{E} = \vec{D}$ is solved by matrix methods and the method of least squares comprising the steps of deriving a separation and inversion filter of the form $\mathbf{F} = (\mathbf{S}^{*}\mathbf{S})^{-1}\mathbf{S}^{*}$, then performing the matrix multiplication $\mathbf{F}\vec{D}$.

9. *(Original)* The method of claim 1, wherein each segment has a duration that is at least as long as the seismic wave travel time down to and back up from the deepest reflector of interest.

10. *(New)* A method of separating the seismic response for each of a plurality N of seismic vibrators operated simultaneously with continuous sweeps, said method comprising the steps of:

(a) obtaining a seismic data record of the combined response signals from all vibrators as detected and recorded by at least one detector, each vibrator having been loaded with a unique continuous sweep signal consisting of $M \geq N$ segments, the i^{th} segment being of the same duration for each vibrator, $i = 1, 2, \ldots, M$;

(b) obtaining a vibrator motion record for each vibrator containing a signature for each vibrator indicative of the motion of that vibrator;

(c) parsing the vibrator motion record for each vibrator into M shorter records, each shorter record coinciding in time with a sweep segment, and then padding the end of each shorter record sufficiently to extend its duration by substantially one listening time;

(d) forming an $M \times N$ matrix s whose element $s_{ij}(t)$ is the padded shorter vibrator motion record as a function of time t for the i^{th} vibrator and j^{th} sweep segment;

(e) parsing the seismic data record from step (a) into M shorter records, each shorter record coinciding in time with a padded shorter record of vibrator motion from step (c);

(f) forming a vector $\vec{d}$ of length M whose element d_i is the i^{th} shorter data record from the preceding step;

(g) solving for $E_j(f)$ the following system of M linear equations in N unknowns

$$S\vec{E} = \vec{D}$$

where $S_{ij}(f)$ is the Fourier transform to the frequency (f) domain of $s_{ij}(t)$ and $D_i(f)$ is the Fourier transform of $d_i(t)$, where $i = 1, 2, \ldots M$ and $j = 1, 2, \ldots N$; and

(h) inverse Fourier transforming the $E_j(f)$ to yield $e_j(t)$.

11. *(New)* A method of operating a plurality N of seismic vibrators simultaneously with continuous sweeps, so that the seismic response for each vibrator can be separated, said method comprising the steps of:

(a) loading each vibrator with a unique continuous sweep signal consisting of $M \geq N$ segments, the i^{th} segment being of the same duration for each vibrator, $i = 1, 2, \ldots, M$;

(b) activating all vibrators and using at least one detector to detect and record the combined seismic response signals from all vibrators;

(c) selecting and recording a signature for each vibrator indicative of the motion of that vibrator; and

(d) sending the vibrator motion record for each vibrator and the seismic data record to be processed by:

parsing the vibrator motion record for each vibrator into M shorter records, each shorter record coinciding in time with a sweep segment, and then

padding the end of each shorter record sufficiently to extend its duration by substantially one listening time;

forming an M x N matrix s whose element $s_{ij}(t)$ is the padded shorter vibrator motion record as a function of time t for the i^{th} vibrator and j^{th} sweep segment;

parsing the seismic data record from step (b) into M shorter records, each shorter record coinciding in time with a padded shorter record of vibrator motion;

forming a vector $\bar{d}$ of length M whose element d_i is the i^{th} shorter data record;

solving for $E_j(f)$ the following system of M linear equations in N unknowns .

$$S\vec{E} = \bar{D}$$

where $S_{ij}(f)$ is the Fourier transform to the frequency (f) domain of $s_{ij}(t)$ and $D_i(f)$ is the Fourier transform of $d_i(t)$, where $i = 1, 2, \ldots M$ and $j = 1, 2, \ldots N$; and

inverse Fourier transforming the $E_j(f)$ to yield $e_j(t)$.

12. *(New)* A method of operating a plurality N of seismic vibrators simultaneously with continuous sweeps, so that the seismic response for each vibrator can be separated, said method comprising the steps of:

(a) loading each vibrator with a unique continuous sweep signal consisting of $M \geq N$ segments, the i^{th} segment being of the same duration for each vibrator, $i = 1, 2, \ldots, M$;

(b) activating all vibrators and using at least one detector to detect and record the combined seismic response signals from all vibrators; and

(c) selecting and recording a signature for each vibrator indicative of the motion of that vibrator.

13. *(New)* A method of separating the seismic response for each of a plurality N of seismic vibrators operated simultaneously with continuous sweeps, said method comprising the steps of:

(a) parsing the vibrator motion record for each vibrator into M shorter records, each shorter record coinciding in time with a sweep segment, and

then padding the end of each shorter record sufficiently to extend its duration by substantially one listening time;

(b) forming an M x N matrix s whose element $s_{ij}(t)$ is the padded shorter vibrator motion record as a function of time t for the i^{th} vibrator and j^{th} sweep segment;

(c) parsing the seismic data record from step (b) into M shorter records, each shorter record coinciding in time with a padded shorter record of vibrator motion;

(d) forming a vector $\vec{d}$ of length M whose element d_i is the i^{th} shorter data record from the preceding step;

(e) solving for $E_j(f)$ the following system of M linear equations in N unknowns

$$S\vec{E} = \vec{D}$$

where $S_{ij}(f)$ is the Fourier transform to the frequency (f) domain of $s_{ij}(t)$ and $D_i(f)$ is the Fourier transform of $d_i(t)$, where $i = 1, 2, \ldots M$ and $j = 1, 2, \ldots N$; and

(f) inverse Fourier transforming the $E_j(f)$ to yield $e_j(t)$.